Efficient 1181nm self-stimulating Raman output from transversely diode-pumped Nd^{3+}: $KGd(WO_4)_2$ laser

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In recent years, stimulated Raman scattering in crystals has become a promising method to efficiently generate laser radiation at new frequencies. Tungstate crystals have received particular attention, because high concentrations of laser-active ions such as Nd^{3+} can be doped in the crystals and self-stimulating intra-cavity Raman action can be achieved [1].

Nd doped $KGd(WO_4)_2$ (Nd:KGW) crystals have high stimulated emission cross-section for laser action, and high Raman gain coefficients for the two strongest Raman transitions ($768cm^{-1}$ and $901cm^{-1}$). Findeison et.al. demonstrated a transversely diode-pumped, self-stimulating, Q-switched Raman Nd:KGW laser, operating on the $768cm^{-1}$ Raman shift; they obtained up to $100\mu J$ output energy at the first Stokes wavelength of 1162nm, for a diode- pump energy of 80mJ[2]. The corresponding optical conversion efficiency from diode to Raman output was less than 0.15%.

In this paper, we report 1.8% efficient, self-stimulating Raman output at 1181nm (corresponding to the $901cm^{-1}$ Raman shift) from a transversely diode-pumped Q-switched Nd:KGW laser. The efficiency is the highest value, to our knowledge, obtained by transversely diode-pumped Nd:KGW Raman lasers.

A Nd:KGW crystal with dimensions $2x5x25mm^3$ and with fairly-high (5 at.%) concentration was transversely pumped in a close-coupled configuration by a 70W quasi-continuous-wave (QCW) diode bar with pulse duration of 120μs and at a repetition rate of 60 Hz. The diode output was delivered to the (uncoated) crystal as a line with dimensions of ~0.2mm × 10mm. A laser cavity was formed by a concave end mirror and a flat output mirror. The end mirror with a radius of curvature of 500mm had high reflectivity (HR) for 1067nm and 1181nm. Various output mirrors were used to optimise the output at the various wavelengths of interest. An acousto-optic modulator (NEOS) was used for Q-switched operation.

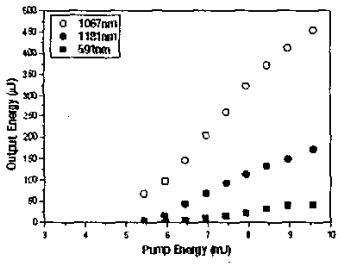

Fig.1 Output energy vs pump diode energy.

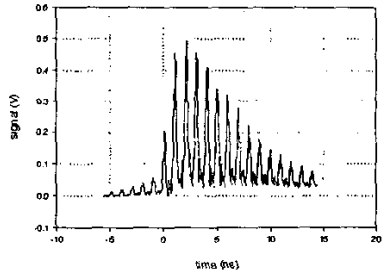

Fig. 2 Temporal profile of first Stokes output

The laser produced up to $450\mu J$ output at the fundamental (1067nm) by using an output coupler with 5% transmission at 1067nm. The lasing threshold was around 5mJ, and the slope efficiency was around 10% with respect to the power from the pump diode. The highest output at the first Stokes wavelength (1181nm) was obtained using an output coupler which was HR for 1067nm and 90%R for 1181nm. Up to $170\mu J$ was obtained, with a slope efficiency of around 4.5%. A maximum yellow output at 591nm was obtained by intracavity second harmonic generation in an LBO crystal (type 1) and using an output mirror which was HR for both 1067nm and 1181nm, and 80% reflecting for 591nm. The results are summarized in fig. 1.

Further improvements in efficiency are expected through refinements to the side-pumped gain module, including the coupling geometry and AR-coating the pumped face of the Nd:KGW crystal. We have also measured interesting Raman pulse shortening by a factor of 10. The fundamental output has duration of ~75ns (fwhm), while the Stokes output is ~7ns (fwhm). The Stokes output is also strongly modulated, as shown in figure 2.

References

[1] I.V.Mochalov, J.Opt.Technol. **62** (1995) 746.
[2] J.Findeisen, H.J.Eichler, P.Peuser, Opt.Commun. **181** (2000) 129.